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Anisotropic Compression of Fibrous Zeolites (Natrolite, Edingtonite, Thomsonite) to 7 GPa

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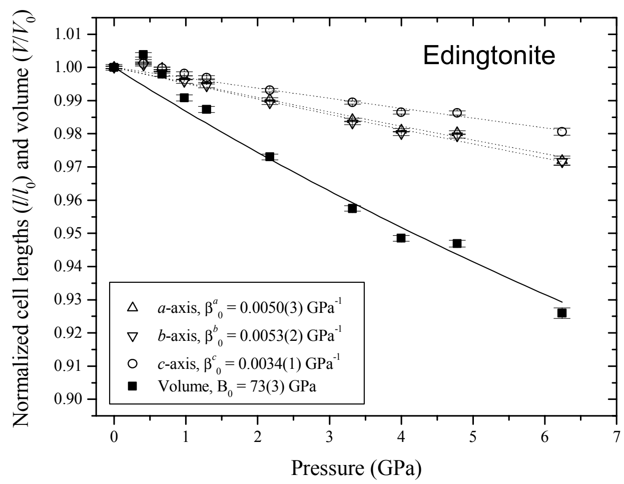
Beamline(s): X7A

Polycrystalline samples of natural edingtonite (New Brunswick, Canada) and thomsonite (Oregon, USA) were studied up to 7 GPa at room temperature using monochromatic synchrotron X-ray and a diamond-anvil cell with methanol:ethanol:water mixture as penatrating pressure transmission fluid. Unlike natrolite (Dutoitspan, South Africa) studied previously using the same condition as used here,[1,2] edingtonite and thomsonite did not show any apparent pressure-induced hydration or phase transitions. All these fibrous zeolites are characterized by anisotropic compression, with the linear compressibility of the fibrous chains (c-axis) as small as one third of those perpendicular to the chains (a-, b-axes); for natrolite, $\beta^{a}_{0=1.5}$ = 0.0086(3) GPa^{-1}, $\beta^{b}_{0=1.5}$ = 0.0091(2) GPa^{-1}, $\beta^{c}_{0=1.5}$ = 0.0028(1) $GPa^{-}1$; for edingtonite, β^{a}_{0} = 0.0050(3) GPa^{-1}, β^{b}_{0} = 0.0053(2) GPa^{-1}, β^{c}_{0} = 0.0034(1) GPa^{-1}; for thomsonite, β^{a}_{0} = 0.0080(2) GPa^{-1}, β^{b}_{0} = 0.0084(2) GPa^{-1}, β^{c}_{0} = 0.0032(1) GPa^{-1}. The pressure-volume data were fitted to a second-order Birch-Murnaghan equation of state using a fixed pressure derivative of 4. As a result of the relatively smaller compression across the chains, the bulk modulus of edingtonite is found to be about 50% larger compared to those of natrolite and thomsonite; K^{EDI}_{0} = 73(3) GPa, $K^{NAT}_{0 = 1.5\ GPa}$ = 50(1) GPa, K^{THO}_{0} = 52(1) GPa. Distance least-squares method was used to model the expected framework, following the observed linear compression behaviors, and the chain-bridging T-O-T angle is proposed to be related to the different compressibility across the chains in each framework type.



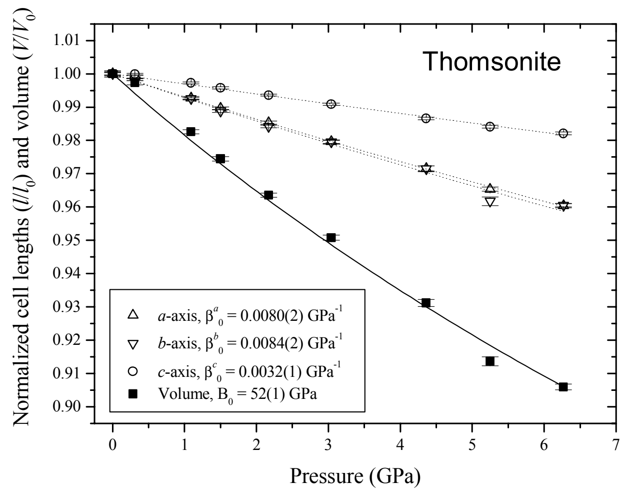


Figure. Pressure dependence of the unit cell edge lengths and volume of edingtonite (upper) and thomsonite (lower), normalized to their ambient pressure values. Continuous lines are fits to the volume data using second-order Birch-Murnaghan equation of state, and dotted lines are fits to the cell length data using linearized second-order Birch-Murnaghan equation of state

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References:

[1] Lee, Y.; Hriljac, J. A.; Vogt, T.; Parise, J. B.; Artioli, G. Journal of the American Chemical Society 2001, **123**, *12732-12733*.

[2] Lee, Y.; Vogt, T.; Hriljac, J. A.; Parise, J. B.; Artioli, G. Journal of the American Chemical Society 2002, **124**, *5466-5475*.